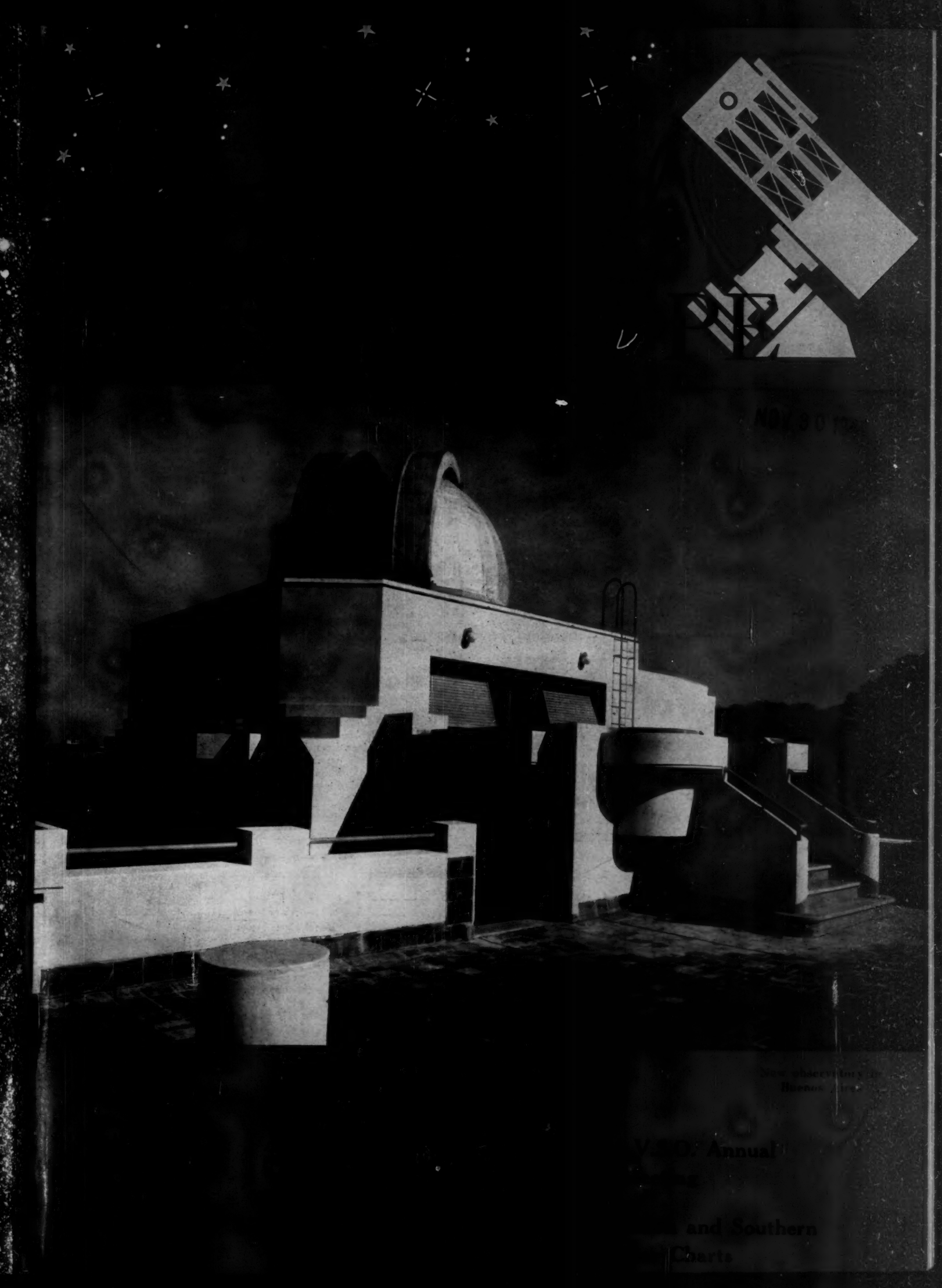




Sky and TELESCOPE

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The Editors Note .

COMPLETION of the third index to **Sky and Telescope**, that for Volume III, and David W. Rosebrugh's statistics concerning his index to **Variable Comments** as presented at the A.A.V.S.O. annual dinner (see page 8), led us to compile some more-or-less vital statistics about our index. The figures hardly compare with Mr. Rosebrugh's results; his self-appointed task of indexing three volumes of **Variable Comments** (1924-1940) well deserves the more searching analysis his energetic mind has given it.

There are 1,046 text page references in the current **Sky and Telescope** index, under 474 items, and 64 cross references to help you find your way around. The authors number 76, and there are 125 references to names of people. Twenty-nine books received full reviews during the year. As might be expected, "Stars" leads all other subject references, 34 items being included in this topic.

This year's index also includes a section for advertisements; 32 advertisers (excluding classified) took space on 133 pages during the year, a substantial and welcome increase, the result of effective work on the part of our advertising director and of inquiries by readers.

Improved reader response has partly resulted from a steady increase in circulation, and some of this, in turn, has come by way of astronomical societies which have recently included the magazine as one of their privileges of membership — groups not mentioned in our editorial of January of this year. These societies include the Burnham Astronomical Society, Chicago; the Detroit Astronomical Society; the Amateur Astronomers Association of Pittsburgh; the Astronomy Study Group of Portland, Ore.; the Wichita Astronomical Society, Wichita, Kan.; the Aldrich Astronomy Club, Worcester, Mass.

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DECEMBER, 1944

COVER: The dome of the new observatory of the Asociacion Argentina "Amigos de la Astronomia," as seen from the northwest. It houses a Gautier refractor with its 215-mm. objective by the Henry brothers, which is a loan from the Observatory of the National University of La Plata. This telescope was originally purchased to observe the transit of Venus in 1882. A considerable portion of the roof of the building is of flat tiles, permitting large observing parties to assemble and to set up portable telescopes. Two small piers for theodolites have been built, one pier showing in the foreground of this picture.

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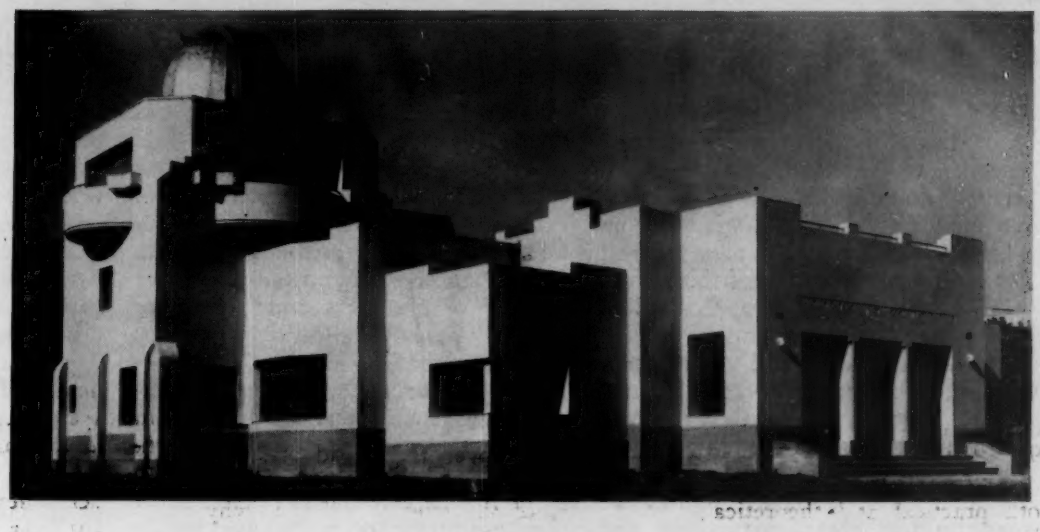
BACK COVER: Saturn is the planet which dominates December skies this year and is an especially attractive object for the observer with a telescope capable of revealing its rings. The current opposition occurs on December 28th, and the rings appear opened nearly to their fullest extent. The back-cover photograph was taken by E. E. Barnard with the 60-inch reflector at Mount Wilson Observatory.

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The land on which the new public building and observatory of the Asociacion Argentina stands may not be sold nor mortgaged. The building occupies about an eighth of the block, and the remainder will be maintained by the municipal park department, thereby assuring a certain degree of isolation for observing the heavens.

ASOCIACION ARGENTINA "Amigos de la Astronomia"

By Felix Cernuschi, *Guggenheim Fellow at Harvard University*

IT IS still true that, according to a metaphor of Sir Arthur Eddington, astronomy is a sort of bird which tries to fly with only one wing. There are a comparatively small number of observatories and astronomers in the Southern Hemisphere, in spite of the fact that its skies are the richest for astronomers. For this reason, and because of the sincere sympathy for the people of Argentina that one finds everywhere in the United States, the news about the completion and the inauguration of the public building and observatory of the Asociacion Argentina "Amigos de la Astronomia" was heartily welcomed by professional and amateur astronomers.

This association was founded in Buenos Aires on the 4th of January of 1929, through the initiative of Sr. Carlos Cardalda, who is called affectionately by the other members "the Patriarch." By the middle of April of the same year, there was published the first number of *Revista Astronomica*, the magazine of the association, and by now the best astronomical periodical written in Spanish. In *Revista* there have appeared excellent articles about different aspects of astronomy, about work in Argentinian and foreign observatories, and many articles of special interest to amateur astronomers. A number of translations of writings by noted foreign astronomers have also been published.

Professional astronomers of the Argentine observatories of Cordoba and La Plata have actively collaborated from the very beginning in the program of the association, as they have recognized the importance of the work of amateurs in astronomy. Among the professional scientists who have most enthusiastically helped the society, we must remember: Felix Aguilar, Jorge Bobone, S. J. Bossolini, Enrique Chaudet, Martin Dartayet, Bernhard H. Dawson, Enrique Gaviola, Juan Hartman, Juan José Nissen, Carlos D. Perrine, Alexander Wilkins. The association has at this writing 263 members. It is undoubtedly the most important Latin-American amateur scientific institution. By that I do not mean, of course, that it cannot learn a great deal from other similar institutions which are older, larger, and have already done fine work in both the popularization and research sides of astronomy. Our association has accomplished an important task in promoting interest for astronomical studies, but there is a great deal to be done in our country.

"Amigos de la Astronomia" has since the beginning organized lectures and conferences, periodical visits to the observatories of Cordoba and La Plata, and an elementary and very interesting seminar in astronomy directed by Dr. Dawson. In April, 1941, the society presented the first South American astronomical exhibition, at which were shown a large collection of telescopes and other astronomical instruments made by amateurs, various astronomical photographs, and other displays.

From the beginning, one of the chief goals of the society was to have its own observatory and public building. This was a very difficult task because there were few members and no official support. But with exemplary enthusiasm and perseverance, a small group of members won out over economic difficulties and succeeded in erecting a splendid and comfortable building with an observatory. This new edifice was inaugurated on the 22nd of last April. It was built on a piece of land, adjoining the centrally located Parque Centenario, given in 1939 by the municipal government of Buenos Aires. Since then, the association has received no further official help. All the expenses of construction, furniture, instruments, books, and the like, were covered by private gifts. The building and furniture alone cost almost 160,000 Argentine pesos (about $40,000). Sr. José R. Naveira, president of the association, with his great interest in the society's educational and scientific purposes, contributed 115,000 Argentine pesos to create a "Home of Astronomy" in the city of Buenos Aires, which was the ideal of the founder of the association. Without this generous gift, "everything would have remained in the world of dreams."

The subcommittee in charge of the construction of the building was composed of Sr. Naveira, José H. Porto, Angel Pegoraro, and José Galli. The building, which was constructed in two years, has on each side of the entrance small rooms for the secretary and meetings of the executive board. Beyond the entrance is the main hall; a central lecture room is 23 by 39 feet, and is adjoined by wings 20 by 24 feet each, to be used normally as museum

and library, but which are virtually continuous with the central room. On the library side there are a classroom and a workshop and laboratory, while the other side has the understructure of the dome. This contains, on a mezzanine floor, living quarters for the caretaker and a guest room where an observer may pass the rest of the night. For plans of the edifice, see *Revista Astronomica,* XII, 288-293, 1940.

Lectures on general astronomy, both practical and theoretical, astrophysics, physics, and mathematics are delivered in the new building. There are also periodic meetings and a colloquium. The observatory may be used by teachers of astronomy and their students. This is very important, for there are still teachers of astronomy in the secondary schools of Argentina who have never seen the sky through a telescope, and so it is not surprising that many students leave high school with Aristotelian views about science in general and astronomy in particular.

The society is going to have a telescope making section and another for the mounting of astronomical instruments. It would be very valuable if the group would try to institute centers for active young observers in different parts of the country, for work on variable stars, meteors, and such phenomena. The awakening of scientific habits of observation and reasoning is essential in Argentina, for the system of education is grounded primarily on memory and verbal training.

International collaboration is absolutely necessary in all branches of science; astronomy is undoubtedly the most international science, not only because the objects of its study are universally observable, beyond the control of any particular race or country, but also because astronomers realize that it is impossible to obtain all the necessary astronomical data from some few countries. A larger number of observers and observatories all over the world is what any good astronomer wants for the progress of the science. This is why scientists in general, and astronomers in particular, are better prepared to understand that the best way to help the cultural and material development of their own country is by working in co-operation in a friendly atmosphere of free thought with other countries. Astronomers can and must do a lot to forward real inter-American intellectual collaboration. The Asociacion Argentina has begun already the development of interest in astronomy not only in Argentina, but also in other South American countries, and we hope this progress will continue.

The real astronomical tradition in Argentina is closely related to that of the United States. In the early days, the only astronomical projects carried on in Argentina were those of the priest, Benaventura Suarez, born in the Argentine city of Santa Fe in 1679. He constructed astronomical instruments and undertook observations for more than 50 years. Then there was Octavio Frabrizio Mossotti, born in Italy in 1791 and graduated in mathematics and physics from the University of Pavia, who went to Buenos Aires in 1827 and established the first observatory in that city. Some of his observations were published abroad. But the beginning of the systematic study of astronomy in our country was in the year 1871, when Don Domingo Faustino Sarmiento, one of our greatest statesmen and educators, brought Dr. Benjamin Apthorp Gould to Argentina to organize and direct the first national observatory in Cordoba. In those days, Sarmiento, who was a great student and admirer of the educational system of the United States, said that in this country "there is no university or even a college without telescopes, like that of Chicago, considered among the best in the world."

The first really important Argentinian astronomical work was the *Uranometria Argentina,* published in 1879, the work of Dr. Gould and his collaborators in Cordoba on the brightness and position of every star down to the 7th magnitude within 100 degrees of the south pole.

The scientific work developed by Dr. Gould was taken up by several astronomers, among them others from the United States. Thus, the United States and Argentina have been working on a good-neighbor astronomical policy in the past. The result has been an improvement in our cultural level, the production of scientific work of international value, and, what is also important, the improvement of the relations between two peoples who are similar in many ways.



The inauguration of the new building took place on April 22, 1944. Here the president, Jose R. Naveira, is speaking. On the platform at the extreme left is Angel Pegoraro, association treasurer and director of "Revista Astronomica." Behind him is Carlos L. Segers, secretary of the society. Next, seated, is Carlos E. Becker, acting secretary of public works and industries, representing the municipal government. Standing behind Sr. Becker is L. M. Gandolfo, alternate council member. At the extreme right of the picture is J. Eduardo Mackintosh, assistant secretary, and seated at his right is Bernhard Dawson, council member and technical adviser. Seated at Dr. Dawson's right is Jose Galli, assistant treasurer; standing behind them is Oscar S. Buccino, a council member.

A BLACK DWARF STAR?

Harvard Announcement Card 697 carries a report from Dr. W. J. Luyten and Dr. P. D. Jose that "from blue and yellow plates taken with the 36-inch reflector of the Steward Observatory [Tucson, Ariz.], the color index of Van Biesbroeck's faint companion to BD +4° 4048 has been found to be +1.4, and the photographic magnitude 19.5, giving a photovisual magnitude of 18.1, according closely with Van Biesbroeck's value of 18.0. This color index not only is surprisingly low for so faint a star, of absolute magnitude 19.3 photovisually, but there appear to be several faint stars nearby which are as red or redder than the proper motion star. This suggests the possibility that this, the star of lowest known luminosity, is a degenerate star, and approaches a 'black dwarf' — it might be a star whose surface temperature corresponds to that of an early M dwarf, but whose luminosity is several thousand times lower."

STARS OR PLANETS?

By Peter van de Kamp, *Sproul Observatory, Swarthmore College*

DURING the past few years several discoveries have been made of unseen companions to nearby stars. Since these objects are of low luminosity and of low mass, the question arises whether they are planets or very faint stars. The purpose of this article is to consider what we mean by the words *star* and *planet*, to outline the observational methods for discovering companions of low mass, and to review the recent results.

STARS are self-luminous spheres of compressed incandescent gases; the radiant energy in the different colors depends on the surface temperature. Stellar luminosities range from over 100,000 to as little as 1/500,000 times the sun's brightness. For the components of several binary stars it has been possible to derive values of the mass;[1] the observed range in stellar masses proves to be very limited. There exists a close relation between mass and luminosity, the fainter stars being less massive, excepting the white dwarf stars. Only comparatively few stars are more than 10 times as massive, and about a thousand times as luminous, as the sun. At present, the smallest known mass for a visible star, 1/7 the sun's mass, is that of the faint red dwarf component of the double star Krüger 60; this is also one of the intrinsically faintest stars, having a candlepower of only 1/2,000 times that of the sun; its surface temperature is about 3,000° K.

On the other hand, the *planets* of our own star (the sun) and their satellites are cool and predominantly solid bodies of small mass, also closely spherical in shape, like stars. They shine almost exclusively by reflected light, although at some time in the distant past they probably were very hot and still are in their deep interiors. In pondering the possible existence of planets outside the solar system, it seems reasonable to restrict the word planet to a *dependent* of a star, that is, to an object of very small mass compared with its primary, and revolving around the latter. This is the case for the solar planets, the mass-ratio planet-sun reaching a value of only 1/1,047 for the heaviest planet, Jupiter. The dependency of the planets in the solar system resulting from the sun's dominant mass is eloquently revealed through Kepler's laws of planetary motion. This same kind of dependency exists for the satellite systems; even for our own "double planet" the moon is only 1/81 times as massive as the earth. In binary stars the masses differ much less, however, the component masses rarely having a ratio smaller than 1/3.

Present data on stars and planets involve strong observational selection effects. The planets near our sun were easily discovered; for the stars, however, possible planetary, like very faint stellar, companions should be very elusive. Suppose that the bright component of Alpha Centauri (magnitude 0.3), a close replica of our sun, had a planet like Jupiter, revolving in a similar orbit. As seen by us, every six years a greatest elongation of four seconds of arc would occur, the planet appearing as an object of the 23rd magnitude. This elongation would be about the same as the separation of Procyon and its faint companion; the latter, although only 10 magnitudes fainter than Procyon, is a very difficult object to observe. Our hypothetical planet certainly would be lost in the glare of its primary, even with a 200-inch telescope.[2] With present observational means, therefore, the chances of a conventional planetary object for even the nearest star to be *seen* are nil.

We should be prepared, however, to extend our tentative definition of a planet as a dark dependent of relatively small mass to include masses larger than that of Jupiter (1/1,047 suns), just as we may find self-luminous stars of smaller mass than the faint component of Krüger 60 (1/7 suns). So far as theory is concerned, there is no reason why such objects, intermediate in mass, could not exist. This matter has recently been discussed by Henry Norris Russell (*Publ.* Astr. Soc. Pac., *55*, 79, 1943; *Astr. Jour., 51,* 13, 1944), who concludes that cosmical bodies less than 1/20 times the sun's mass should generally be unobservable by their own light even under the most favorable conditions. Their surface temperature is expected to be less than 700° K, which is about the limiting temperature for visibility of a hot body. As the component of a binary star, such an object would generally remain invisible even by any radiation derived from heating by the neighboring primary star. Though its reflected light might be appreciable, it would defy any visual detection because of the comparative brilliance of the primary.

We shall accept a generalized definition which will include these relatively cool objects by adopting Russell's critical value of 1/20 of the sun's mass as a conventional borderline between visible stars and the *per se* invisible bodies which we shall designate by the general term *planet*. It is the *amount of mass*, therefore, which determines whether a body should be classified as a "star" or as a "planet"; size is of secondary significance.

IN practice, a search for very faint, or dark objects of low mass resolves itself into a search for companions of relatively nearby stars.

[1] For visual binaries, the sum of the masses is found from the mean linear separation a and the period P through the relation: $M + m = a^3P^{-2}$, using the conventional astronomical units of mass, space, and time. This total mass is divided over the two components by localizing the mass center through its uniform motion.

[2] The chances of visual discovery of a planet having 10 times the diameter of Jupiter, and hence five magnitudes brighter, would hardly be better. A larger orbit might take the planet out of the glare but would diminish its reflected brilliance; the latter would increase for a smaller orbit, but that again would be outweighed by the increased glare.



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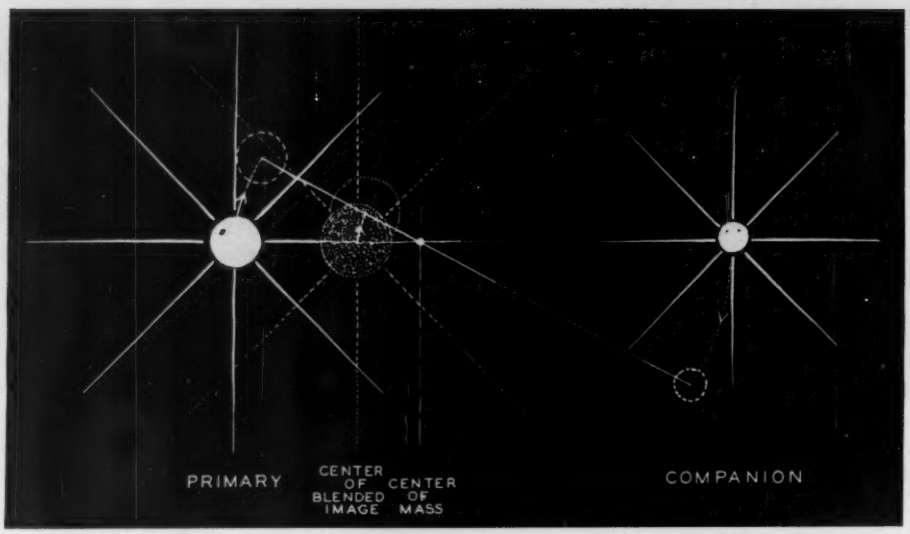
In 12 years the fainter component of Krueger 60 completed about one fourth of its orbit, as shown by these photographs by Barnard at Yerkes Observatory. Illustration adapted from Baker's "Astronomy."

We first note that faint, *visible* stellar companions, outside the glare of their primary stars, will continue to be discovered by careful telescopic scrutiny of nearby stars. Also, those having wide separations from their primaries will be found by a systematic search for objects sharing the proper motion of the primary. Scores of such companions have been found and their number promises to increase —particularly toward very faint objects. In the past decade, many faint, close companions were discovered by Gerard P. Kuiper. Of the proper-motion companions we mention the very faint star recently found by G. Van Biesbroeck in the comprehensive survey under way at the McDonald Observatory. This object, at an angular distance of 74″, shares the proper motion of the star BD +4° 4048 (distance, 19 light-years); it is of the 18th magnitude or nearly nine magnitudes fainter than the primary. The large separation of companion and primary (over 400 astronomical units) precludes the possibility of the former shining by reflected light. Here we are dealing with a bona fide star although we do not know its mass. This is the intrinsically faintest star known, having only 1/500,000 times the sun's luminosity, and being only 700 times as luminous as Jupiter.

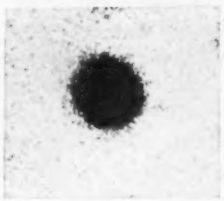
Unseen companions can be most effectively detected through the study of their gravitational effect on the motion of known stars or stellar systems.[3] (In certain cases, significant information may be obtained if primary and companion form an eclipsing binary.) This perturbing effect is revealed as a Keplerian orbital motion of the visible star relative to the center of mass of itself and the unseen companion. The size of this perturbation orbit is a measure for the mass of the companion. The perturbation can be studied by direct visual or photographic observations, which represent the so-called astrometric approach, or by spectroscopic measures of the changing velocity in the line of sight. The latter method favors the discovery of stellar companions of which hundreds have thus been found. Since only the projection in the line of sight is observed, the unknown inclination severely limits the possible mass determinations for the individual stars.

Most promising for the discovery of unseen companions of low mass is the photographic method applied to nearby stars. A long-focus instrument of large aperture is used, and a large number of exposures on any one night are taken so that a positional accuracy of 0″.01 or better is obtained. The plates are measured on a long-screw measuring machine; for single stars the positions are referred to a set of faint "background" stars; for known visual binaries the relative positions of the two components are measured. The astrometric method, involving measurements in the plane of the sky, permits the determination of the orientation of the perturbation orbit. However, this method has its difficulties also. The photographic star images are anywhere from 1″ to 3″ in diameter. Most of the recently discovered perturbations have a total amplitude of less than 0″.1, so that generally the minute orbital drama is played on a stage much smaller than the size of the star images.

Now the reflected light of a *planetary* companion would be negligible and have no effect on the observed position of the star. But the light from a faint, unseen *stellar* companion may seriously reduce the size of the perturbation orbit. The companion may be only a magnitude or two fainter than the primary, faint enough to make its visual (or spectroscopic) detection extremely difficult, but it would draw the light center of the unresolved binary away from the primary, closer to the center of mass. The resulting photographic images would still look round, but the effective orbit of the light center (called the photocentric orbit) would be *smaller* than the orbit of the primary. Since the size of the latter is a measure of the mass of the companion, the observations would give a *lower* limit for this mass. One should be cautious, for instance, about interpreting a very small photocentric orbit as the result of an unseen planetary companion unless additional evidence is available.[4] Subsequent visual detection of any companion would, of course, give complete information about its mass and luminosity.



This sketch shows the location of the measured positions relative to primary, companion, and their center of mass. It is evident that the perturbing effect caused by a faint stellar companion is less for the observed light center than for the primary star itself. Hence, the measured perturbation for an unresolved astrometric binary yields a lower limit for the companion's mass.



A photographic star image, enlarged 75 times, taken by Strand with the Sproul 24-inch refractor. The size of the image (2″) is caused mostly by atmospheric turbulence and photographic action. For a close, unresolved binary the center of the image represents the effective light center of primary and companion.

[3]The significance of the spectroscopic method was realized long ago, as exemplified by the following quotation (Campbell and Curtis, Lick Observatory *Bulletin*, III, 145, 1905):

"The velocity of our sun through space varies slightly, because it is attended by companions,—very minute ones compared with the invisible bodies discovered by spectroscopic binary systems. It is revolving around the center of mass of itself and its planets and their moons. Its orbit around this center is small, and the orbital speed very slight. The total range of speed is but three one-hundredths of a kilometer per second. An observer favorably situated in another system, provided with instruments enabling him to measure speeds with absolute accuracy, could detect this variation, and in time say that our sun is attended by planets. At present, terrestrial observers have not the power to measure such minute variations. As the accuracy attainable improves with experience, the proportional number of spectroscopic binaries discovered will undoubtedly be enormously increased."

[4]*Publ.* Astr. Soc. Pac., *55*, 263-269, 1943; *Astr. Jour.*, *51*, 7-11, 12-13, 1944; *P. A.*, *51*, 175-185, 1943; *P. A.*, *52*, 53-70, 1944.

BEFORE mentioning the recent results, we shall review the classical development of the astrometric discovery of unseen objects within our solar system and beyond. The direct telescopic discovery of Uranus by William Herschel in 1781 was followed in 1846 by the discovery of Neptune. The latter was first recognized as an unseen object from perturbations in the orbit of Uranus not accounted for by the space-time-mass relations of sun and known planets. This gravitational discovery, performed independently by Leverrier and Adams, was immediately confirmed by the telescopic observation of the planet close to the predicted place. A search at the Lowell Observatory led to the subsequent discovery of the distant solar planet Pluto, first found in 1930 as a faint image on search photographs and afterwards seen as a faint telescopic object.

Bessel had also been working on the Neptune problem; however, his death in 1846 prevented the completion of this work, which would have been a natural sequel to his earlier discoveries. For Bessel was the first astronomer to discover unseen objects by the gravitational method. In 1844, he announced the discovery of companions to the nearby stars Sirius and Procyon, from a study of irregularities in the proper motion of these stars derived from meridian circle positions. That the objects could not be seen, or might be truly dark, did not deter Bessel from his interpretation. Wrote he (*Monthly Notices, 6,* 141, 1844):

"But light is no real property of mass. The existence of numberless visible stars can prove nothing against the existence of numberless invisible ones."

Bessel's analyses were tested by others and confirmed. His interpretation was not verified until nearly two decades later (1862) when the companion of Sirius was seen by Alvan G. Clark with the 18-inch refractor now at the Dearborn Observatory. The very faint companion of Procyon was not seen until 1896 by Schaeberle with the Lick 36-inch refractor.[5]

The implications of his discoveries were well realized by Bessel. From his letter in the *Monthly Notices* we again quote:

"For, even if a change in motion can, up to the present time, be proven in only *two* cases, yet will all other cases be rendered thereby liable to *suspicion;* and it will be equally difficult, by observations, to free other proper motions from the suspicion of change, and to get such knowledge of the change as to admit of its amount being calculated."

The only other pre-photographic discoveries were based on micrometric measures of the visual binary systems Zeta Cancri and Xi Ursae Majoris. First studied by Seeliger (1888) and Nörlund (1907), respectively, and since confirmed, the perturbations in the orbital motions of these two objects are interpreted as the effects of close, *still unseen* stellar companions.

Of current photographic investigations, we mention the repetition of early parallax series, commenced by the author at the Leander McCormick Observatory; the comprehensive search for variable proper motion by Harold L. Alden at the Johannesburg station of the Yale Observatory; the Sproul Observatory program, devoted to all single stars nearer than 33 light-years and within reach of the 24-inch refractor, and to K. Aa. Strand's program on certain nearby double stars.

For several single and double stars the photographic method has already revealed perturbations.[6] For most of these, provisional orbits have been derived with periods ranging from about one year to several decades. None of these objects has been visually resolved. The lowest mass value, 1/60 times the sun's mass, is found for the third component in the visual binary 61 Cygni, discovered by Strand. This limiting mass value falls well within our arbitrary definition of planets. Most of the other unseen companions, however, must be faint stars, with lower limits up to more than one half the sun's mass.

This type of investigation is of great observational delicacy and the reality of the perturbations in each case should be carefully tested through future observations. It is well to remember that some unsubstantiated discoveries appeared shortly after Bessel's results; Spica, for example, was suspected of having a perturbation and an orbit was computed! Other results obtained since have been proven spurious and can be explained by systematic errors in the observations and by premature judgment.



Bessel, 100 years ago, predicted the existence of unseen stars.

The gravitational method for discovering and studying faint companions of low mass is more powerful than the direct visual approach; for very low masses, however, limitations set in again. Take, for example, the hypothetical Jupiter-like companion to the bright component of Alpha Centauri, mentioned in the beginning of this article. The resulting perturbation would have a range of less than 0".01 and hence would be hovering on the threshold of detection. Only faint stellar companions and relatively massive "planets" can be studied, while the discovery of less massive planets is at present a practical impossibility. As a general rule, we may state that it would be exceedingly difficult to find companion masses less than 1/100 times the sun's mass, even for the nearest stars.

THE photographic search for unseen companions has hardly begun; the next decade or so should witness considerable progress in this field. We are beginning to realize the implications of the recent results for our outlook on the general property of gregariousness among stars. The large abundance of double stars has been

(Continued on page 22)

[5]For both Sirius and Procyon the orbital characteristics are now well known. As shown by Bessel, Sirius and its companion revolve around each other in 50 years; for Procyon the period of revolution is 40 years. The companion of Sirius is known to be a white dwarf. Because of its faintness little is known of Procyon's companion. Although intrinsically 10 times as faint as the faint component of Krüger 60, it is 25 times as bright as the nearby star Wolf 359 and 250 times as bright as Van Biesbroeck's star of lowest known luminosity. Its visibility and large mass insure its classification as a star.

[6]Established perturbations for single stars, mostly red dwarfs, are Ross 614 (1936) and Ci 1244 (1943) found by D. Reuyl at the McCormick Observatory; Wolf 358, discovered by Carl L. Stearns at the Van Vleck Observatory and confirmed by Alden; Delta Aquilae and Ci 1988, found by Alden; and Barnard's star (1939), Lalande 21185 (1941), and BD +5° 1668 (1943) studied at the Sproul Observatory. Perturbations in known binary stars have been found by Strand for Zeta Aquarii, Mu Draconis, Xi Bootis, and 61 Cygni.

A. A. V. S. O. Annual Meeting

By Herbert M. Harris

Astronomical Society of Maine

FOR many years the annual meeting of the A.A.V.S.O. has been held at Harvard College Observatory, and this year was no exception. The 33rd annual meeting, called for October 6th and 7th, proved to be most successful in spite of current generally restricted conditions. Many members and guests escaped from their work long enough to make the journey to meet old friends, see new astronomical gadgets, hear of the latest astronomical findings or discoveries, be recipients of attendant pleasantries, and to partake of the gastronomic offerings.

Friday evening the society was royally entertained by the Bond Astronomical Club, whose president, Dr. A. E. Navez, presided. At this, their 20th anniversary, a majority of the 14 who have been presidents of the Bond Club were on hand. Each presented, in light or serious vein, a report of some happenings during his term of office, giving official and some less official reminiscences. The celebration meeting was enlightening and of much interest to the A.A.V.S.O.

On Saturday, the handling of business and programs was effected with almost military precision by A.A.V.S.O. President Roy A. Seely, assisted by the new gavel just presented him by the association's inventor, David W. Rosebrugh. This versatile secretary of the group in turn had his records ready, and read them with a zest that opened the business meeting in truly animated style.

Recorder Leon Campbell made a comprehensive report. Principally, he states that, despite fewer observers, this year's observations exceed those of last year, although the total is not up to prewar standards. He reported a total of 32,767 observations contributed for the year ending September 30, 1944, with 70 observers taking part in the work. Cyrus Fernald for the third time heads the list of contributors, with a total of 5,316 estimates, or an average of 443 observations on 204 variables per month. R. P. deKock, Cape Town, South Africa, with 2,878 observations, and Leslie C. Peltier, Delphos, Ohio, with 2,215, took the next honors. Over the 1,000 mark were Messrs. Cousins, Hartman, Holt, Meek, Nadeau, Rosebrugh, and Sill, and Mrs. W. M. Kearons led the women observers with 1,152. The A.A.V.S.O.'s veteran observer, T. C. H. Bouton, now in his 88th year, deserves honorable mention for 366 observations submitted. And E. H. Jones, faithful and often high-scoring observer for many years, was unable to attend this meeting, the first he has missed in 22 years.

The society has only an estimated two years to go before reaching the goal of a million total number of observations, Mr. Campbell continued. In the past third of a century there have accumulated 944,000 observations. With the cessation of hostilities in Europe, it is hoped many of the foreign observers will again make valuable contributions.

Reports from the various A.A.V.S.O. committees were heard. Miss Alice H. Farnsworth, chairman of the occultations committee, reported an encouraging note in the number of observations made by those doing occultation work. There were 36 such reports in 1941, 49 in 1942, 58 in 1943, and 41 to October 1st in 1944.

President Seely was elected for another term, and councilors elected were Helen S. Federer, Herbert M. Harris, Samuel R. Parks, and Emil A. Sill.

The highlight of the morning session was flashed by none other than Charles Elmer, who showed the members that, while a high man in the manufacture of optics, he is at the same time a rebuttal lawyer of no little force. With gentle persistence, he inquired of Mr. Campbell whether a Merit Award was to be made this year, and if not, why not. The recorder, a man perfectly capable of taking his own part, extemporaneously and convincingly enumerated a number of reasons why no award was to be made. And then from the blue sky, so to speak, and before he knew what had happened, Mr. Campbell was recipient of the eighth Merit Award. The decision to confer the honor, it seems, was arrived at by a very sub-rosa committee within the council, working in utter secrecy. The award, beautifully designed by Fred E. Jones, was placed on view at the meeting, marking the first time the certificate was engrossed before announcement of the making of a Merit Award, a fact more than a little surprising to Mr. Campbell.

Saturday afternoon was devoted to a session for papers. Neil J. Heines gave an instructive talk on the "how" of sunspot study by the amateur. He showed an observing bracket for holding a screen attachment to a telescope, complete plotting charts, files and graphs, and he extended cautions for solar observers to follow. The A.A.V.S.O. plans to undertake in the near future a program for the serious amateur who wishes to carry on day-to-day observations of sunspots.



Leon Campbell, recorder of the American Association of Variable Star Observers.

The author then gave a short paper on "The Observatory Clock" in which he explained how an amateur may set and regulate a pendulum clock so that it will be a good sidereal time base.

Secretary Rosebrugh displayed his "new-departure" finder which can be attached close to the eyepiece of a Newtonian reflector; its efficiency is dependent upon a roof prism and erecting lenses.

Dr. Sergei Gaposchkin gave a short talk on his recent work with unusual variable stars.

Following the afternoon session, a very enjoyable tea was served through the courtesy of the observatory staff.

The annual banquet was held at the Harvard Faculty Club on Saturday evening. Of the 60 persons present, the state of Maine had a representation of 16, or 27 per cent!

An interesting blackboard talk by Dr. James G. Baker described the features of the recently publicized instruments designed by the Russian optician, D. D. Maksutov. The typical Schmidt camera design is varied by using an "achromatic meniscus" correcting lens, consisting of spherical surfaces on both sides. It has a slight negative power for rays passing through, but no appreciable color effect for systems of practical size and focal length.

Again at the dinner Mr. Rosebrugh described one of his current efforts, the indexing of the three volumes of *Variable Comments,* and the author gave a short account of the history of the Astronomical Society of Maine.

Dr. Harlow Shapley gave his annual summary of the highlights and lowlights of astronomy which are always so eagerly awaited. The saddest lowlight was the loss of photographic plates en route from South Africa to Harvard. The sinking of a single ship disposed of one fourth of a year's work at Bloemfontein.

Among the highlights, the Harvard director mentioned the strange Comet Oterma 1943a, which has an asteroid-like orbit, between Mars and Jupiter, of only four degrees inclination and 14 per cent eccentricity; the discovery of an atmosphere around Titan, Saturn's brightest satellite; the voyage to Peru of Mexican astronomers to view the January eclipse; the finding of the advance of perihelion of the earth's orbit predicted by relativity; and the observation at Climax, Colo., with Harvard's coronagraph, of spicules on the sun.

Beyond the solar system, the increasing frequency of double and multiple stars is making history; the intrinsically faintest star is about one millionth as bright as the sun! Spectroscopic analyses of many stars by Yerkes astronomers are revealing them to be what might be called "shell" stars. Globular clusters have recently had their distances revised, M13 now being set at about 31,000 light-years away, while M4 may turn out to be only a few thousand light-years distant, considerably closer than hitherto suspected. Last, but not least, Dr. Shapley looked to the resolution of the nucleus of the Andromeda galaxy and its companion galaxies (see News Notes, this issue) as indicating the extent of forward progress during 1944.

The INDEX for Volume III

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ASTRONOMICAL ANECDOTES

Binocular Eyepieces and Optical Delusions

VERY so often there arises the old question of binocular vision at the telescope. The discussion may start out quite sanely with the very safe and true statement that everyone feels more relaxed when using both eyes, so the use of a device permitting both eyes to be concentrated on the object under examination might be recommended. Then somebody gets excited and begins to talk about stereoscopic effects and all bets are off. It ceases to be an argument about what ought to be done; it becomes a recital of individual idiosyncrasies.

There are two notes, one *pro,* one *con,* on this subject in the May, 1942, issue of the *Journal* of the British Astronomical Association, many members of which are very accomplished observers. The ideas there expressed coincide with my own opinion and experience; indeed, I believe it would be difficult to defend successfully any ideas far removed from these.

In the first place, any stereoscopic effect is quite spurious. It is quite analogous to the spurious stereoscopic effect to be obtained by viewing with only one eye any sharp photograph or drawing containing proper perspective. The one eye seems to say to the brain, "Now look here, if we look at this scene with two eyes, we shall see depth in the picture; the depth is there, we know, so even if we look with only one eye and can't see it, we'll pretend we see it." I have occasionally been amazed when examining lantern slides through an eyepiece, to check the definition and graininess, to find that the details of the picture take on depth not at all present when the slide is viewed with two eyes. The eye and brain combination, with many years of experience behind it, is very easily misled into inserting stereoscopic effects where none exist.

Binocular microscopes can be made to reveal true stereoscopic effects, a fact which undoubtedly misleads some of the proponents of binocular eyepieces for telescopes. By forcing the light which enters the right side of the objective to come to the eyepiece for the left eye, and the light which enters the left side of the objective to arrive at the eyepiece for the right eye, true impressions of depth can be obtained. But in the instance of a microscope, the object is close to the objective, and one side of the thing can be seen by one of the sides of the objective and not by the other. Why anyone should insist that a binocular eyepiece on a telescope can show anything but a mentally illusory stereoscopic effect is very puzzling.

Sometimes we hear the argument that if we look with two eyes the image should be brighter. This is certainly unsound, for even if the prisms or mirrors used to produce two beams for the eyepieces worked with 100 per cent efficiency, there would be only a certain amount of light available—that amount admitted by the objective, which after all has a fixed area —and no trick can amplify this. Indeed, the two eyepieces will absorb and lose by reflection twice as much as a single eyepiece.

Of course, this last argument is irrelevant, for unless the observer has eyes which differ greatly, he will not see any more with two eyes than with one. Try it for yourself. Don't squint and so strain the eye left open; cover one eye with an eye patch or a card held close, and use only one eye at a time on the stars, without any instrument. Each eye will see as well as the other and as well as both together! The light entering the two eyes apparently never combines to double the amount entering one eye. The sole purpose of two eyes is to give stereoscopic effects in ordinary affairs — and perhaps to provide a spare, if one goes bad!

I have found, in speaking with a few of my friends through the years, that one eye is likely to be very strongly favored over the other in use at the telescope, sometimes through mere habit, but sometimes because that eye has proved superior. I have a choice for myself; when I want to see small detail on a moderately bright object, I use my left eye; when I want to detect the presence of a very faint object, as a comet or a nebula, I use my right eye. All the synapses between my left eye and my brain and muscles seem better developed, for at times while guiding with my right eye, while relieving the left ordinarily used, I find a tendency to do a poor job. Perhaps the fact that I can close my right eye without perceptible strain on the powers of the left, while I find it very difficult to close the left eye without squinting with the right, has something to do with this. And now, of course, I have confessed that I am one of those benighted heathen who don't like to leave both eyes open at the telescope. Why, anyone will tell you that it is silly to close one eye!

R.K.M.

NEWS NOTES

By Dorrit Hoffleit

CORONAL LIGHT

At its June meeting the British Astronomical Association discussed a Russian paper by N. Betenska on "The Source of Light during a Total Solar Eclipse." Although the solar corona is the one most apparent source of light during a total eclipse, it is responsible for only a minute portion of the general illumination of the sky. The average width of the path of the moon's shadow, less than 100 miles, is of the same general order as the effective depth of the atmosphere. Hence much light from neighboring atmospheric regions is refracted and scattered into the region of totality.

Photometric measurements during the Russian eclipses of 1936 and 1941 indicate that sky brightness ranged from 1/10,000 to 7/10,000 of the brightness without eclipse, while the coronal light was only 4/10,000,000 or 5/10,000,000 of daylight. Thus the ratio of coronal to sky light was only 1/1,000; numerous older determinations are in general agreement with these new results.

SOME OF OUR NEIGHBORS

One of the observational problems that most astronomers expected could be solved only with the new 200-inch telescope has been successfully tackled with the Mount Wilson 100-inch by Dr. W. Baade. Making long exposures on red-sensitive photographic plates, he has succeeded in resolving into stars the nebulous nucleus of the Andromeda galaxy and its two elliptical companions, Messier 32 and NGC 205. The *Griffith Observer* attributes this success to the Los Angeles-Pasadena dimout, which allowed longer exposure times than were previously possible. Combined with this is the even more important fact that red-sensitive plates will record red stars to a fainter magnitude limit than can be recorded on blue plates. It happens that the brightest stars in these hitherto unresolved systems have a high enough color index to take advantage of the qualities of the red plates. Whereas the blue-sensitive plates had recorded stars only to magnitude 21.0, stars of color index greater than +1.0 could be photographed on the red plates to a sensibly lower limit.

Dr. Baade has found that the brightest stars recently resolved in the three Andromeda systems have an average color index of +1.3 and a photographic magnitude of +21.3. Achieving his results required some ingenuity, however. While red-sensitive plates exposed through a yellow filter (recording wave lengths greater than 5000 angstroms) are much faster than the combination actually used, such a faster combination records so much diffuse (auroral) sky light that the faint stars become obliterated. Using ammoniated Eastman 103E plates behind a Shott RG2 filter, a combination photographing only light of the narrow spectral region between 6300 and 6700 angstroms, Dr. Baade found that longer exposures, while necessary, were possible since the night-sky colors were excluded. His results on the resolution of the three systems of the Andromeda group were achieved about a year ago, but they have been published only in the September *Astrophysical Journal*.

Meanwhile, Dr. Baade has applied his observing technique to two other hitherto amorphous elliptical galaxies, NGC 147 and NGC 185. They are separated in the sky by only 58 minutes of arc, and form a dynamically related pair which may be associated with the Andromeda nebula only seven degrees away. From their radial velocities and the globular clusters associated with them, it seemed probable that they are nearby galaxies and hence worthy of attempts at resolving them into stars. In this Dr. Baade has been successful, showing that their distances are comparable with that of the Andromeda system.

Previously, we knew 10 stellar systems as our near neighbors — galaxies within a distance of about 240 kiloparsecs. These two galaxies whose distances are now determined bring the total to 12. Other as yet unresolved elliptical nebulae may also become recognized as members of the local group. Any elliptical nebula, in order to be resolved into stars with the 100-inch and Dr. Baade's present technique, must be within 300 kiloparsecs, a distance which happens to be the adopted outer boundary for membership in the present recognized local group of galaxies.

Unlike some of the spirals whose brightest stellar members are the hot, giant *O*- and *B*-type stars of absolute magnitudes —5 or —6, the brightest members of NGC 147 and NGC 185 are identified by their color indices as reddish *K* and *M* stars with absolute magnitudes only a little brighter than —1. In appearance these two elliptical galaxies might be thought related to the globular clusters. The total luminosities of the brighter globular clusters are, moreover, about the same as for the smaller elliptical galaxies. NGC 147 and NGC 185 have absolute magnitudes of —10.3 and —10.6. That the two types form entirely different cosmological categories is demonstrated, however, by the extreme difference in size between them. The average diameter of the globular clusters is of the order of 1/10 of a kiloparsec, as compared with 10 times this value for the faintest ellipticals.

INDIA'S METEOR SCHOLAR

Mohd. A. R. Khan, of Begumpet, Deccan, India, appears to be an ardent meteor enthusiast. When, in the 1930's, he took up meteoric astronomy, little work in this field was being done in India. We have just received a pamphlet from him entitled "Meteoric Showers, Past and Present." This is a second edition of a paper originally published in the *Journal* of the Osmania University in 1935. The compilation, in chronological order of meteor showers, of abstracts on the showers observed since 867 B.C. is a valuable reference source.

In a recent account by Prof. C. P. Olivier, president of the American Meteor Society, of the numbers of meteors observed in 1943 (exclusive of the Perseids), we note that the most active member of the society in that year was Prof. Khan of India. Observing on 81 nights, he had plotted the paths of 1,044 meteors. The next two highest numbers plotted by a single observer and reported to the American Meteor Society were 112 on 13 nights and 111 on six nights.

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BEGINNER'S PAGE

Man and His Expanding Universe — XII

By Percy W. Witherell



The Large Magellanic Cloud.

FERNANDO MAGELLAN, in planning his trip to the Spice Islands by a southwesterly course, was assisted by Ruy Faleiro, an astronomer. When the latter, after casting his own horoscope and finding it unfavorable, decided not to go, the world lost a chance for an early technical description of the Large and Small Magellanic Clouds. These objects were so named by Hevelius in honor of the Great Circumnavigator, whose sudden death in the Philippines prevented his writing his own memoirs; these were recorded, however, by Antonio Pigafetta, a volunteer associate.

Although the location of these celestial clouds, at two corners of an equilateral triangle which they form with the south celestial pole, was useful to navigators, little was known of their structure for many centuries. Certainly, no one dreamed how useful they would become in our time as laboratories in which to establish standards for the measurement of the universe.

The Englishman, Thomas Wright, wrote in 1750 that the Milky Way is only one of many systems of stars, though the others may not resemble the galaxy or each other in structure. "That this in all probability may be the case is in some degree made evident by the many cloudy spots just perceivable by us . . . in which, although visibly luminous spaces, no one star or particular constituent body can possibly be distinguished. These, in all likelihood, may be external creations, bordering upon the known one, too remote for even our telescopes to reach."

In 1873, a *Manual of Astronomy* by Henry Kiddle gives a description of "the Greater and Lesser Cloudlets. The former is in Dorado; the latter in Toucan. These objects are distinguished for their great extent, the larger covering a space of about 42 square degrees, and the smaller being of about one-fourth that extent, but of greater brightness. The telescope of John Herschel decomposed them into separate stars, star clusters, and numerous distinct nebulae. In the larger cloud, Herschel counted 582 single stars, 46 star clusters, and 291 nebulae; in the smaller cloud, 200 single stars, 7 star clusters, and 37 nebulae. In the immensity of their extent and diversity of objects which they present, they are only comparable to that apparently the greatest of all clusters, the Milky Way."

In 1900, the Bruce 24-inch photographic refractor at the Harvard station, then at Arequipa, Peru, began to record the southern skies on large-sized plates. The Magellanic Clouds showed tens of thousands of stars and hundreds of star clusters and gaseous nebulae. Then Miss Henrietta Leavitt, at the Harvard Observatory, started the series of events which has so amazingly increased our knowledge of the size of the known universe. She began to record the apparent magnitudes of the stars on the Bruce plates, publishing in 1906 a list of 808 faint variables in the Large Cloud and 969 in the Small. Later she showed that the period of each variable (time between maxima) had a distinct relation to its luminosity.

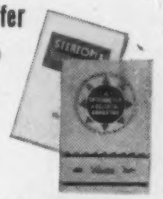
Ejnar Hertzsprung, of the Netherlands, showed that the Cepheid variables of the Milky Way are giant (highly luminous) stars, and if the Cepheids in the Magellanic Clouds were considered to be giants also, as seemed likely, they must be very distant to appear so faint. Then Harlow Shapley gave additional proof by a study of the short-period Cepheid variables in the globular clusters, and finally produced a diagram relating the period of a Cepheid to its absolute luminosity.

Here then was a standard to measure the distances to the faint objects. Assuming that all Cepheid variables of the same period are of equal absolute luminosity, the distance can be computed by a simple relationship between the absolute and apparent magnitudes. The results were startling. The distance to the Large Magellanic Cloud is 75,000 light-years (a light-year is six million million miles) and that to the Small Cloud is 84,000 light-years. Their centers are about 30,000 light-years apart.

Recent plates taken in red light have shown a haze of stars around the main clouds, indicating the possibility that the two systems are nearly in contact or even contained in a common network. The Magellanic Clouds and our own galaxy have a mutual gravitational relationship and the haze of stars surrounding each system may be actually in contact with the others.

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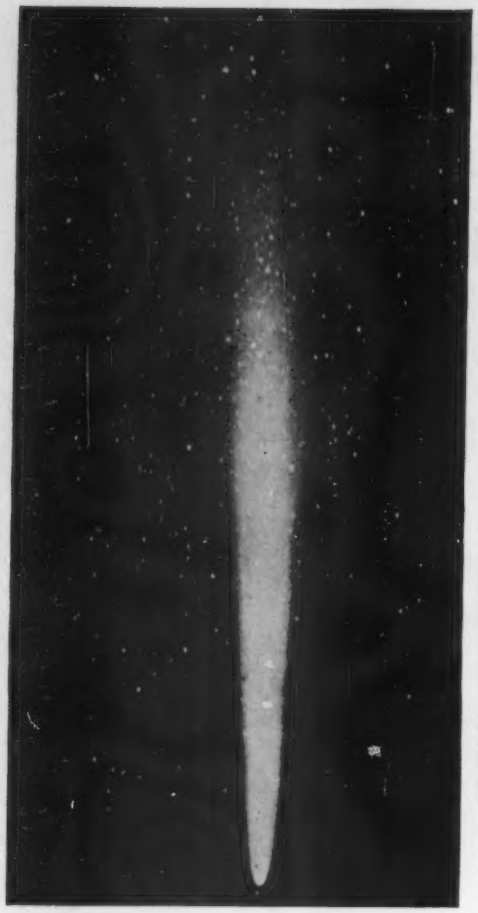
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A comet as great as Halley's might have appeared when Christ was born.

IT IS Christmas again, the time of the Christmas star. One of the highest values of the great religious festivals—one might almost say a universal value, whatever the creed—is that these festivals for a brief moment, at least, give to the scattered individuals of a country or a race a special feeling of unity and oneness, of belonging together. The Christmas star itself as a symbol was originally, so far as we can determine, a five-pointed star. The symbolic meaning of the five-pointed star is believed to be that of man as an entity, as an individual, the points representing the head, the two arms, and the two legs. Combining within itself the symbolic representation of the individual as well as the essence of a great religious festival, the Christmas star is an ideal symbol for what we feel most deeply at Christmas time.

Scattered over the world today, flung as if by a mighty hand across its great oceans and its curving continents, are millions of men and women in service. They come not only from America, and they will all be thinking of home at this Christmas season. Many of them will be remembering the star on the top of a Christmas tree, or the star lighted above the altars of their churches. And as they lie on battlefields, or tramp across dangerous enemy country, the cold stars of winter may look less cold because of that one star that shone so long ago.

Although the Christmas season is one which is widely celebrated in many countries and on all continents, there is in the average mind a great deal of confusion concerning the real facts about Christmas. According to the best Biblical authorities, the date of Jesus' birth is not known, but may be placed anywhere between 4 B.C. and 11 B.C. We know that it could not have occurred later than 4 B.C. because in that year King Herod died, and according to the Bible story Jesus was born before the death of this tyrant. There is some slight evidence, however, that the birth may have taken place as early as 11 B.C. Perhaps the most commonly accepted date is 6 B.C.

Quite naturally there has been a general impression among laymen that the birth of Jesus coincided with the start of the year 1 which is generally regarded as the beginning of our era. According to common sense this certainly should have been the case, since we refer to dates before the beginning of our era as B.C., or Before Christ, and dates after that as A.D. (Anno Domini). An early mistake in calendar computation was made, however, by the chronicler Dionysius Exiguus, an abbot of Rome in the sixth century. This error has resulted in the uncertainty as to the date of Jesus' birth.

Whoever reads the story of the first Christmas, sings the Christmas carols which have become so dear to our hearts, or notices the stars sprinkled lavishly on Christmas cards and decorations, must wonder as to the real nature of that bright star which the Wise Men saw so long ago. Because so many questioning minds have considered this problem through the ages, it is interesting to review the possibilities. Unfortunately, no one, religious authority or astronomer, can definitely say just what the Star of Bethlehem was. But this lack of clarity as to the actual identity of the star would not seem in any way to invalidate its meaning or its beauty as a symbol.

Many orthodox Christians believe the Star of Bethlehem was a miracle. The belief in signs and symbols goes back to very ancient times and we find even in modern days a great tendency in this direction. To some people the Christmas story would lack its authentic ring if their belief in a miraculous apparition should be destroyed.

THE CHRIS

BY MARIAN

Popular interest in astronomy reache
mystery of the Star of Bethlehem sti
Buhl and Hayden planetariums are to
which might "explain"

With the onset of modern Biblical criticism and scientific clarification there are many people, on the other hand, who can no longer be satisfied by the suggestion of a miracle Christmas star. Astronomers have during the years been so constantly asked for an explanation that it will perhaps be of value here to make several suggestions, remembering that they are *only suggestions* and that no definite criteria of judgment can be brought to bear upon them.

There are few people, however unaware they may be of the heavens above them, who have not at some time or other noticed a particularly bright star shining in the pastel-colored west of the evening sky. More often than not this very bright object proves to be not a star at all, but the planet Venus, the brightest of those nine worlds which travel regularly in their paths around the sun. Venus at its brightest is more brilliant than anything else in the sky except the sun and the moon, and is startling in its lucid beauty. This planet, like all the others, shines not by any light of its own, but because it reflects the light of the sun. The same could be said of the planet Earth, for if you were to travel out into space you would see the earth illuminated, too, by reflected sunlight. But Venus is brighter than any of the other planets because it is surrounded by exceedingly heavy, white clouds which are an almost perfect reflector for sunlight. The clouds which surround Venus never break up, as do those in the earth sky. Venus is sometimes so brilliant that objects in its light cast a shadow.

It has been suggested that Venus may have been the bright celestial object seen by the Wise Men who were waiting for a sign from heaven. This suggestion, however, brings up various difficulties which should be considered. Although astronomy was not in what we would consider an advanced stage, the more educated people of those days were familiar at least with the *appearance* of the sky. The Wise Men were regarded as prophets, and as such were required to keep track of and interpret celestial

ISTMAS STAR

ARIAN LOCKWOOD

reaches its peak in December, when the
em stirs men's thoughts. Audiences at the
are told of the various astronomical events
plain" the Christmas star.

changes. The common belief was that whenever any event of great importance to the Hebrews was about to occur, God would place a sign in the sky. Hence, any unusual or extraordinarily brilliant object would be noticed by them and considered of great significance.

In the case of Venus the Wise Men must have been extremely familiar with the "comings and goings" of this bright planet, even though they did not in all probability understand why it appeared for a brief space in the morning sky, disappeared in the light of the sun, and then reappeared in the evening sky for a few months. They must have been aware of it and realized that it was not a new and strange object. It can be said for this point of view, though, that Venus even to a seasoned observer is a miraculously brilliant and beautiful object.

One of the most interesting possibilities is that of the conjunction of three planets in the constellation Pisces, the Fishes, in the spring of 6 B.C. In 7 B.C. Jupiter and Saturn, two of the planets or "wanderers," had closely approached each other in this constellation which from time immemorial has been held sacred to the Jews. This in itself would have been an event of great interest to soothsayers and prophets. It was generally believed at that time that when God wished to send a heavenly sign to the Jewish people that sign would appear in the constellation Pisces. Gradually Jupiter and Saturn after drawing apart a little came closer together, and were then joined in the spring of 6 B.C. by the third planet, Mars, the three forming a triangle of great brilliance although rather close to the sun. The triangular formation involving these three planets takes place about every 800 years, but it is doubtful that the prophets had any record of the preceding occurrence. To them it must have been indeed a startling event.

The Star of Bethlehem may have been a particularly brilliant meteor, or fireball. There are probably few persons who have not at some time seen a "shooting star." Shooting stars, however, are not stars at all, but are tiny bits of matter, literally countless in number, called meteors. When these particles collide, as they frequently do, with the atmosphere of the earth, we see them as streaks of light flashing across the heavens. The sudden flare is caused by friction when a meteor passes at a rate of many miles a second through the earth's atmosphere. Ordinarily if the meteor is small it is consumed in its swift journey. Occasionally a larger one survives in part that devastating speedy rush. When a meteor lands upon the earth it is then known as a meteorite. Billions of meteors are now believed to strike the atmosphere of the earth every 24 hours, but only occasionally do we see the especially brilliant ones or fireballs.

If the Wise Men, who at the time were watching for a sign from God to announce the coming of the Messiah, happened to see a fireball leaving behind it perhaps a brilliant blue train of light, they might easily have interpreted this as their sign. There are on record many fireballs which have lighted up the night sky as brilliantly as the sun but, of course, only for a brief moment. We have no definite record of a spectacular fireball at this time, but since the time itself is not specifically defined but extends in possibility over a period of eight years, this fact does not prove anything one way or the other.

One of the most spectacular and amazing astronomical phenomena which appear from time to time is the nova or "new star." Stars are suns like our own sun but very much more remote from the earth. This remoteness accounts for their considerably lesser brilliance and size as we see them. The sun and the stars are enormous balls of incandescent gas about whose origin and history modern astronomers know very little. It is believed by some, however, that many if not all stars explode at least once during their lifetimes. Such an explosion frequently increases the brilliance of a star thousands of times, resulting sometimes in its outshining any other stellar object or planet in the sky. If the Wise Men suddenly discovered a star rapidly increasing in brightness over a period of days, they would most certainly have regarded it as worth watching and perhaps as the expected sign.

Many people now alive remember the brilliance of Halley's comet in 1910, and the suggestion has been made by scholars that the Wise Men may have seen a comet which came to be known as the Star of Bethlehem. In those days any bright celestial object was called a "star." According to Chinese records—for the Chinese were fine astronomers—such a comet did appear around this time. We have no details concerning this comet, but if it happened to possess a long and brilliant tail, the Wise Men might have regarded it as the finger of God pointing in the direction they should go.

But the fact still remains that these possibilities are all conjecture. For still no one knows what the Star of Bethlehem was. Its real and its great value would seem to lie in the fact that it has symbolized to a large part of mankind for nearly 2,000 years the finest and most lofty ideals.



When the Hayden Planetarium projector is run back to show the skies of 6 B.C., the planets Mars, Jupiter, and Saturn array themselves in a triangle over New York's skyline.

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The explorations described in this volume cover distances of some hundreds of millions of light-years now reached by the greatest photographic telescopes. Richly illustrated by unusual pictures. 126 Illus. 229 Pages. $2.50. (1943) By *Harlow Shapley.*

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It probes into the atmospheres of stars and even digs into their interiors. 150 Illus. 323 Pages. $2.50. (1943) By *L. Goldberg* and *L. H. Aller.*

BETWEEN THE PLANETS

It summarizes our knowledge of comets, meteors, asteroids and meteorites, describes the latest discoveries and considers problems yet unexplained. 106 Illus. 222 Pages. $2.50. (1941) By *F. G. Watson.*

EARTH, MOON AND PLANETS

A discussion of the possibilities of life outside the earth, and a planet finder and star chart, are included. 140 Illus. 293 Pages. $2.50. (1941) By *F. L. Whipple.*

THE MILKY WAY

Problems related to the past and future of our galaxy are discussed. Large scale photographic maps are included. 93 Illus. 204 Pages. $2.50. (1941) By *Bart J. Bok* and *Priscilla F. Bok.*

THE STORY OF VARIABLE STARS

This book introduces the reader to the technique of observations and then analyzes the present state of our knowledge of variable stars. Tables are included. 82 Illus. 226 Pages. $2.50. (1941) By *L. Campbell* and *L. Jacchia.*

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BOOKS AND THE SKY

THE UNIVERSE AROUND US
Sir James Jeans. The Macmillan Company, New York, fourth edition, 1944. 297 pages. $3.75.

THE UNIVERSE AROUND US is a perennial favorite among popular expositions of astronomy. It was first issued in 1929, and the intervening 15 years have seen, if not the greatest, at least the most rapid expansion of astronomy within recorded times. Four successive editions have kept pace with the advances, and much of the fourth has been rewritten.

Sir James' book is welcomed for two reasons. He has an immense facility for illustrative imagery; his word pictures bring his thoughts to life for the most uninstructed reader. There is no appeal to the technical jargon of science—the author is not afraid to put his exotic actors into everyday clothes. The layman with a taste for science will not fail to enjoy the book.

Another quality interests the scientific man. Even though all the material that is treated may be familiar, a popular exposition by one of the leaders in theoretical research is of primary interest, not for the information it conveys, but for the attitude it reveals. In a technical paper the processes of thought are more skillfully concealed, but in a book like the present one it is possible to see them at work.

Sir James is at his best when he writes of "Exploring in Time," the third of his seven chapters. The age of the universe, the theory of relativity, have been his own subjects for several decades, and the masterly touch is evident when he writes of them. "Stars," the fourth chapter, gives a lively picture of the star as an individual. The last three chapters of the book deal with the much more difficult evolutionary problems: "Carving out the Universe," "The Solar System," and "Beginnings and Endings." The astronomer of today, especially one who is primarily in contact with observations, is almost completely at a loss as to origins in the solar and stellar systems. It might be expected that Spitzer's work would be mentioned in connection with the former (even though it renders obsolete much of what has been written), and Spitzer and Whipple have also made significant contributions to the latter.

The first two chapters, "Exploring the Sky" and "Exploring the Atom," give full play to the author's facility with words, and he makes much of the opportunity, for they abound in happy verbal illustrations. The pictorial illustrations, however, are below the level that should be expected. Plate XV (Stellar Spectra) is an antique which should be replaced by one of the really fine specimens of modern stellar spec-

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troscopy; it is a pity to turn to the latest Mount Wilson and Yerkes photographs of stars and nebulae and not to make use of their spectra, which demand just as much refinement in photography and reproduction if their great beauty is to be fitly displayed. Figure 8 is a shock to the student of variable stars. It is frankly schematic, but excellent light curves of variable stars are available by the hundred. In the legend to the figure, Nu Lacertae appears instead of (presumably) V Lacertae. Most glaring, however, is the error of reproducing the light curve of RS Ophiuchi to illustrate irregular variables—the light curve is nothing like the modern curves of RS Ophiuchi, and the star is a recurrent nova (one of the very few known); it may vary irregularly at minimum, but that is not the same thing as being a typical irregular variable.

The most serious criticism of the book is, however, that in spirit it fails to keep step with the times. The descriptions in the first chapter do not see the universe with the eyes of today. And the references to recent and current work betray a very fragmentary coverage. To speak of thermo-nuclear reactions and not to mention Bethe is to stage Hamlet without the prince. There are many ascriptions of ideas and observations, but they are incomplete. And it is disappointing to note a careless attitude toward the spelling of proper names: Bothe, Goposchkin, Houtermanns, Wise (presumably Wyse, but the index reference is incorrect) are avoidable blemishes.

CECILIA PAYNE-GAPOSCHKIN
Harvard College Observatory

NEW BOOKS RECEIVED

FROM STAR TO STAR, *Eric P. Kelly*, 1944, *Lippincott*. 239 pages. $2.00.

A novel for young people of university life at Krakow at the time Copernicus was a student there.

PRODIGAL GENIUS: The Life of Nikola Tesla, *John J. O'Neill*, 1944, *Ives Washburn*. 326 pages. $3.75.

A biography of one of the great men in electrical research, an inventive genius who literally electrified the world. He discovered the rotating magnetic field and the principle of alternating current, and fathered the modern system of power transmission. The author is science editor of the New York *Herald Tribune*.

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by LOU WILLIAMS
Department of Geology
Stephens College, Missouri

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Because of the death of Theodore E. Jaslerski the following items are for sale: patterns, drawings, grinding and polishing machine, all specially made tools, glass blanks, castings and so forth. Phone evenings or write E. Jaslerski, 3222 N. Hamlin Ave., Chicago 18, Ill. Keystone 5589.

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GLEANINGS FOR A.T.M.s

MAKING YOUR OWN TELESCOPE

From Start to Finish—2

By Allyn J. Thompson

Theory of the Foucault Test. This method of testing a concave reflecting surface was devised, about the year 1850, by the French physicist, Jean Foucault, also famed for the pendulum experiment. The impressive features of this test are its simplicity and extreme sensitivity. Foucault's theory was that if an artificial star (illuminated pinhole) be placed at the center of curvature of a spherical mirror, all of the rays from it that fall upon the mirror are perpendicular to its surface, and by the law of reflection, will be returned along the same paths and form an image of the pinhole on the pinhole itself. Of course it could not be examined in this position, but if the pinhole were shifted to one side (we shift it to the right), the image would be shifted a corresponding distance to the left. Now if a knife edge be cut at right angles into this image, all of the rays are at once intercepted. Were the illuminated mirror viewed from the right in Fig. 8a, it would darken instantly all over. But if the curve on the mirror deviates the slightest amount from spherical, then all of the rays are not reflected to a common focus. Instead, rays from zones of different curvature will meet in slightly separated points along the axis of the reflected cone of light, Fig. 8b. The knife edge could nowhere be placed so as to intercept all of the rays at once, and to the eye viewing the mirror, those parts from which rays had been intercepted would appear dark, while the other parts would still appear illuminated. By exploring along a small range of the axis of the cone with the knife edge, and measuring these radii, it is possible to tell what our curve is, almost to the millionth part of an inch.

For a paraboloidal mirror, the difference in length of radii of any zone and the center zone is equal to the formula $r^2/2R$, where r is the radius of the zone, and R the radius of curvature of the center zone.* For our 6-inch f/8 mirror, the difference of radii of the center and extreme edge zones is .047". The radius of curvature of the center zone is, of course, twice the focal length of the mirror.

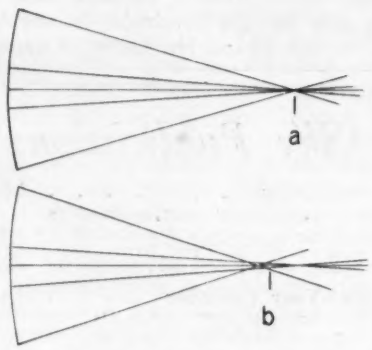


Fig. 8. The observer's eye is at the right in this diagram.

III — MIRROR GRINDING

Strokes. It is assumed that a cellar or other room in which the temperature is fairly constant is available. Grinding, even polishing, may be done almost anywhere, but testing and figuring can only be carried on under conditions of uniform temperature.

There are three motions that the optician must employ in order to preserve a perfect surface of revolution on his mirror. First, the back-and-forth grinding stroke produces the curve. Second, the mirror must be rotated to produce this curve on all diameters. Third, the worker must walk around the barrel (or rotate the tool) to employ all diameters of the tool. While the directions of these last two motions are not important, it is perhaps safest if they are counter to each other. It is not necessary that they be performed with machine-like uniformity, nor to run oneself dizzy in their doing. Take six or eight strokes, rotate the mirror a trifle, and shift to a new position for the next strokes.

A "full-diameter" stroke is one that carries the edge of the mirror to the center of the tool. A "one-third" diameter stroke carries the mirror's edge one inch beyond the edge of the tool at each end of the stroke, consequently the total length of the stroke is 1/3 diameter. A "one-half" stroke carries the edge 1½" over the tool, and so forth. The length of stroke is constant, whether performed diametrically, or over chords of the tool.

What Abrasive Does. If we place a grain of Carborundum between two disks of glass and slide one over the other, a rolling action is imparted to the grain, and as its sharp corners impact the glass surfaces, fragments are chipped out, leaving pits. The Carbo

*In the test described here, the knife edge only is moved along the axis. Hence it must be moved twice as far as would be the case if both knife edge and pinhole were moved together. Thus, the formula for movement of the knife edge is r^2/R. Corrections measured by this equation are frequently referred to, loosely, as differences of radii. The true difference of radii is only half this amount.

Actually, the centers of curvature of the outer zones of a parabola do not lie on the axis at all. The intersection of the radius with the axis, which is what we are really measuring, is referred to in this article as the radius.

grain also breaks down in size until effective grinding ceases. Increasing the rolling speed merely increases the rate at which the grain breaks down, but if the pressure is increased, larger chips are knocked out of the glass. If the Carbo is applied too thickly, the individual grains are not free to roll, but are dragged en masse around the work, scratching and scoring as they go, until most of them have been pushed over the sides, and the rest worn down to a size where their efficiency is destroyed. Some amateurs apply their abrasive so thickly that it resembles the frosting on a cake. This is a needless waste, and as a result the amount of grinding obtained is out of proportion to the effort. Apply the abrasive thinly, and use plenty of pressure. About 80 strokes per minute is a good speed, calling a stroke in this instance the combined back-and-forth motion. Working in this manner, we can remove glass rapidly with a minimum expenditure of elbow grease and Carborundum. Enough water should be used to keep the work wet. Add water from time to time as the abrasive breaks down. In rough grinding it is a waste of time to break the abrasive down fine. The purpose is to remove glass, and when the sound of coarse grinding ceases, fresh abrasive should be added. Flushing off the accumulation of "mud" occasionally will speed up the work. This is important with the finer abrasives.

How the Curve Is Obtained. To produce a concave curve on the mirror blank, it is ground, face down, on top of another disk of glass called the tool. By using diametrical strokes of a length that will bring the edge of the mirror to the center of the tool, at the end of the stroke, Fig. 9 top, the pressure per square unit of surface, and hence the

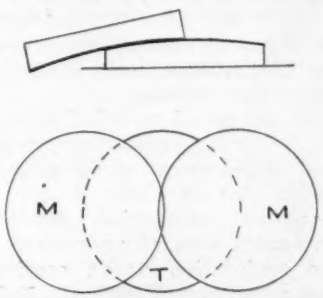


Fig. 9. The long stroke formerly used in rough grinding.

abrasion, is much greater than when the disks are centered on each other. This results in faster grinding at the center of the mirror and the edges of the tool, and we find that the upper disk becomes concave, and the lower one convex. It is interesting to note that gravity alone would bring about this condition, without the application of pressure, but of course, at a much slower rate. On account of the long stroke used (a shorter one would slow the process) the surfaces are not in contact, and are not spherical. The reason is that the edge zone of the tool is roughly three times greater in area than the central zone of the mirror, so there is a proportionately greater removal of glass from the center of the mirror. They "fit" together somewhat as shown in Fig. 10, which is exaggerated to show the hyperboloidal figure (see Fig. 17) of the mirror, and the oblate figure of the tool. They are brought to a spherical figure by wearing back the edges of the mirror. This is accomplished by means of a short stroke, in the early use of which the radius



Fig. 10. The result of rough grinding with a long stroke: mirror hyperbolic, tool oblate.

lengthens slightly. The reason for this is apparent from a study of Fig. 10.

This is an old and reliable method of obtaining the curve, but requires an unnecessary amount of glass to be removed, and we shall grind our mirror by the quicker, more conventional method to be described.

The upper edges of the tool must be beveled all around with the Carborundum stone for about 1/16", and as the surface is ground down, causing the edge again to become sharp, the bevel must be renewed. This is important, to prevent chips breaking off the sharp edge, chips which are apt to get between the disks and cause scratches.

We Go to Work. Have the pail of water placed conveniently near. Shake a few drops of water on the barrel top, and place on it several sheets of newspaper, with sprinkles of water between them, and lay the tool in the center. The wet paper will provide enough adhesion to prevent the tool from sliding about during grinding. Apply some #80 Carborundum around the edge zone of the tool, as that is where the grinding will begin. Add water, and place the mirror on the tool so that its center is about ½" inside the edge. We will use the one-third stroke, and grind on chords of the tool, so that the center of the mirror is carried around the edge somewhat as in Fig. 11a. We shake a few drops of water on the work, and take a half dozen chordal strokes, rotate the mirror, shift to a new position, and work on another chord. The pressure should be applied over the center of the mirror, but do not permit the mirror to teeter over the edge. If the pressure were applied too far in (Fig. 11b) the hollowing out would be slowed, although gravity would eventually do it for us. After two or three trips around the barrel, wash and dry the mirror, and try the template. When the curve in the small central area of the mirror seems right, we take the next series of strokes on chords farther in on the tool. Spread the abrasive now over a wider edge zone, move the mirror in so that its center is about 1" inside the edge of the tool, and grind as before. Apply plenty of pressure for quickest results.

Frequent renewing of abrasive is nec-

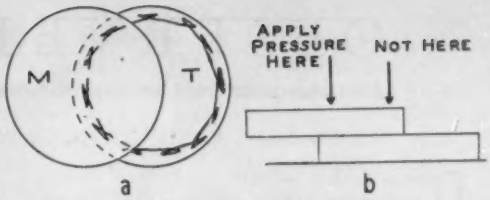
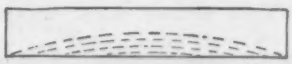


Fig. 11. Correct stroke for rough grinding.

essary in the early stages, as much of it is pushed over the edge without being used. We can scoop up all of this accumulation later, put it in a jar of water, stir, and pour off the muddied water. The unused abrasive at the bottom of the jar can be reclaimed.

When the widened curve on the mirror fits the template, we move the mirror in another ½", and grind until the extending curve again conforms to the template. If at any time the curve becomes too deep, move the mirror in considerably, then continue with the one-third strokes. The curve should just extend to the edges of the mirror when it is grinding center over center

Fig. 12. Steps in grinding.



on the tool, and the curve will have been achieved by the steps shown in Fig. 12. The mirror will hardly be spherical, but will probably have a wavy surface, and the one-third stroke, center over center, must be continued until contact has been established. One to two hours of work with #80 should give the curve.

How to Determine Contact. Numerous bubbles are seen between the disks during the grinding, with the larger

(Continued on page 22)

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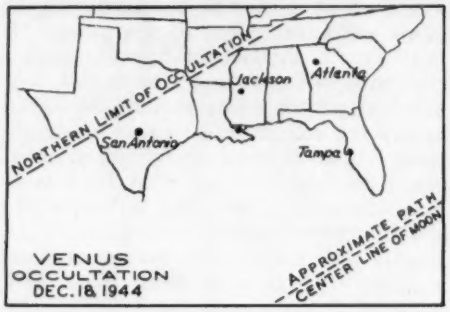
Two Fine Occultations for Southern Observers

By Jesse A. Fitzpatrick

DECEMBER affords observers in our southern states the unusual opportunity of observing occultations of the two most beautiful planets, for on the 2nd of the month the moon passes in front of Saturn and on the 18th in front of Venus. An occultation of Venus, to my mind, is the most beautiful sight in the sky, except a total solar eclipse. On the other hand, the telescopic sight of Saturn and its rings gradually disappearing behind the moon's limb can hardly be surpassed.

The accompanying chart shows the approximate limits of the Venus occultation, which will occur at the times given below for certain cities. The figures are: immersion, position angle; emersion, position angle; moonset. All times are C.W.T. Jackson, Miss., 8:17 p.m., 17°; 8:58 p.m., 303°; 9:12 p.m. New Orleans, La., 8:13 p.m., 28°; 9:03 p.m., 292°; 9:17 p.m. Atlanta, Ga., 8:17 p.m., 22°; 8:59 p.m., 300°; 8:51 p.m. Tampa, Fla., 8:12 p.m., 48°; 9:10 p.m., 273°; 8:51 p.m. Fort Worth and Dallas will observe only very close conjunctions, but Austin and San Antonio will be favored. At Miami and Charleston the event will happen close to moonset, but might be seen by careful observers. At Tampa the immersion will be 60° from the moon's north pole.

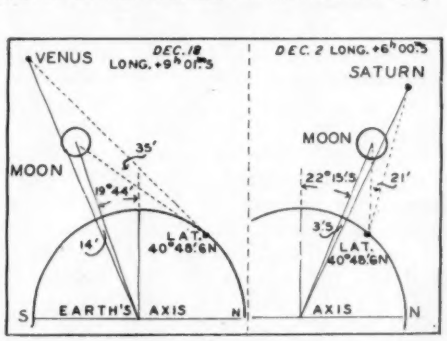
The apparent diameter of Venus, 16".5, would make the planet take about 40 seconds of time to disappear if the immersion were near the middle of the "side" of the moon; but since most of the observers in the United States will see the occultation well above the center, the contact will be a more-or-less glancing one and part of Venus will reflect some light for a period much longer than 40 seconds. This feature should be especially noteworthy in this instance as the moon is a crescent, 3½ days old.



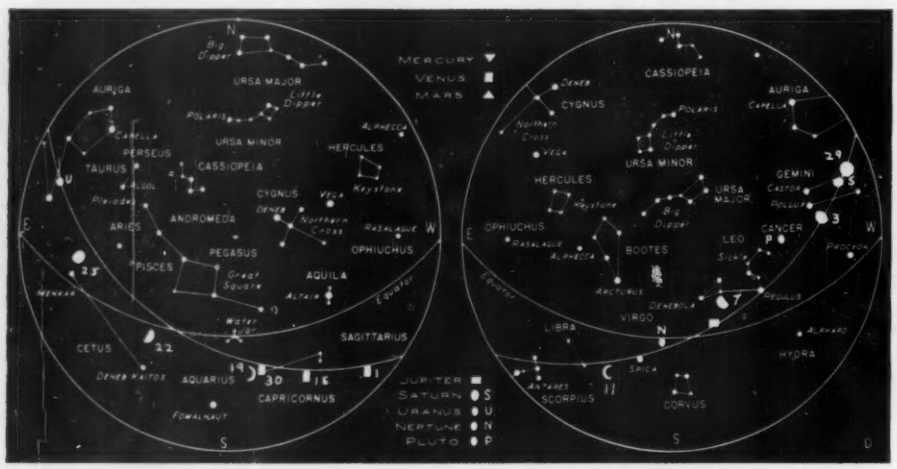
In the case of Saturn's occultation, New Orleans and Jackson are almost exactly on the longitude of geocentric conjunction. Therefore, the middle of the occultation will occur when the moon is on the celestial meridian of those places. At New Orleans the occultation will last 64 minutes and at Jackson, 46 minutes. Immersion occurs at 2:26 a.m. C.W.T., position angle 43° at New Orleans, and emersion at 3:30 a.m., 314°. At Jackson immersion is nine minutes later and emersion nine minutes earlier. The moon will be two days past full.

Farther north. the conjunction will occur on the local meridian at 3:37 a.m. for such places as Memphis and St. Louis. The separation between the planet and the moon will become larger for more northerly places. The moon's apparent path at this time is so nearly due east that an observer in the Mississippi Valley and at the same latitude will see the same separation as observed at New York City, namely, 22 per cent of the moon's diameter.

One of the questions asked most frequently by correspondents concerns the apparent displacement of the moon relative to a star or planet at the time of geocentric conjunction. Some observers cannot seem to understand why a close conjunction or an occultation may not occur even though the **Ephemeris**, as in this case, shows Saturn to be 3′ north of the moon (it is really 3′.5) on December 2nd. On the accompanying sketch I have placed the observer at the latitude of New York City



THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 8:30 a.m. on the 7th of the month, and at 7:30 a.m. on the 23rd. At the left is the sky for 6:30 p.m. on the 7th and for 5:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury will be at greatest eastern elongation, 21° 9′, on December 4th. This will not, however, make for favorable observation in mid-northern latitudes.

Venus, in Sagittarius and Capricornus, will be at magnitude —3.7 at the end of the month. On the 30th, it will be 54′ north of Delta Capricorni. The planet and the three-day-old crescent moon will be very near each other during the early evening of the 18th, but the moon will set 38 minutes before an actual conjunction occurs. If we were permitted to see this conjunction from our local station, we would observe Venus just touching the northern tip of the crescent; see special article.

Earth reaches heliocentric longitude 90° at 7:15 p.m. on December 21st; solstice.

Mars is too near the sun for observation.

Jupiter is in Virgo, and will be 32′ north of Beta Virginis on the 13th.

Saturn, in Gemini, will be in opposition to the sun on December 28th, when its distance from the earth will be 748,-352,400 miles. The inclination of the rings to our line of sight will be 25°.7, and we will view their under, or southern surfaces. See the accompanying article for details of the December 2nd conjunction, which is an occultation in Texas.

Uranus is in Taurus, and will be in opposition on December 3rd.

Neptune is in Virgo.

but at the longitude of the geocentric conjunction. These figures will vary for places east or west, so that for Saturn, the 21′ increases to 22′ at New York City itself, and for Venus the 35′ decreases to 15′, but the conjunction takes place below the horizon.

In the case of Venus, the **Ephemeris** shows the planet 14′ south, but our observer at 41° north will see it 35′ north of the moon's center, or a displacement of 49′, which is considerable. A moment's study of this diagram ought to be worth while; note, however, that no attempt has been made to show proper relative distances or sizes, and that the angles have the values marked on them, but have been exaggerated for clarity.

PHASES OF THE MOON

Last quarter ..December 7, 10:57 a.m.
New moon ....December 15, 10:34 a.m.
First quarter ..December 22, 11:54 a.m.
Full moon ....December 29, 10:38 a.m.

OCCULTATIONS FOR TEXAS

Predictions are for longitude 98° 0′.0 W., and latitude 30° 0′.0 N. The data include: date, name of star, magnitude; G.C.T. in hours and minutes, **a** and **b** quantities in minutes, and position angle, at immersion; G.C.T., **a** and **b** quantities, and P.A., at emersion.

Dec. 1, 372 B Tau, 6.1; . . .; 2:10.1, —0.1, +1.5, 247°.

Dec. 2, BD +22° 1416, 6.3; 4:18.2, —0.3, +2.2, 51°; 5:21.1, —1.8, +0.2, 288°.

Dec. 2, Saturn, —0.1; 7:10.6, —1.7, +3.6, 37°; 8:09.6, —2.7, —2.8, 314°.

Dec. 2, a Gem, 5.2; 12:01.7, —0.4, —3.2, 143°; 12:51.7, —1.4, —0.5, 234°.

Dec. 4, 39 Cnc, 6.5; 9:10.7, —2.7, +1.9, 67°; 10:26.2, —2.0, —3.0, 322°.

Dec. 4, 40 Cnc, 6.5; 9:12.1, —2.7, +1.3, 75°; 10:34.9, —2.1, —2.5. 315°.

Dec. 4, 102 B Cnc, 6.5; 9:37.1, —2.2, —2.8, 142°; 10:54.5, —3.1, +1.0, 250°.

Dec. 5, 8 Leo, 5.9; 13:42.8, +1.0, —5.7, 181°; 14:16.4, —3.3, +1.7, 231°.

Dec. 19, Venus, —3.7; 1:16.2, +0.7, +2.9, 10°; 1:53.0, —1.9, —3.5, 308°.

Dec. 20, 152 B Cap, 6.5; 0:46.7, —1.6, —0.3, 76°; 1:56.4, —0.6, +0.3, 231°.

Dec. 25, 389 B Cet, 6.3; 7:03.7, —0.8, +1.7, 27°; 7:49.6, —0.3, —2.1, 294°.

Dec. 27, 68 Tau, 4.2; 9:03.4, —0.8, —0.6, 80°; 10:05.5, —0.2, —0.8, 265°.

A LUNAR APPULSE

The moon will pass through the penumbra of the earth's shadow on the night of December 29th, visible principally to observers in the Pacific Ocean and the eastern hemisphere. At the maximum phase, it will nearly contact the umbra, at which time the moon will be near the meridian at Tokyo and Adelaide, in a position below the horizon for observers in most of North America.

GEMINIDS

Maximum for the Geminid meteor shower will be reached about the 12th of December. This is one of the best showers of the year.

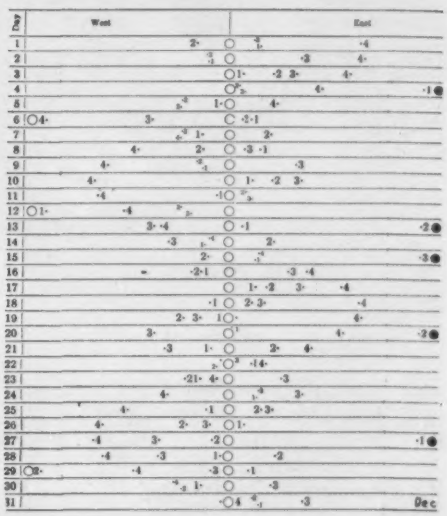
MINIMA OF ALGOL

Dec. 9, 6:26 a.m.; 12, 3:15 a.m.; 15, 0:04 a.m.; 17, 8:53 p.m.; 20, 5:43 p.m.; 29, 8:10 a.m.

JUPITER'S SATELLITES

On December 3rd and 17th, the four bright moons will be east of Jupiter. On the 12th after 6:53 a.m. and on the 27th prior to 4:23 a.m., they will all be on the west side. On the 3rd, 17th, and 27th, they will be in numerical order, with I nearest the primary.

Jupiter's four bright moons have the positions shown below at 6:00 a.m., E.W.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris and Nautical Almanac.**



OCCULTATIONS—DECEMBER, 1944

Local station, lat. 40° 48′.6, long. 4h 55m.8 west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
Dec. 1	5.9	BD +20° 1105	5:55.3 a.m.	129°	6:46.0 a.m.	231°
2	6.3	BD +22° 1416	1:04.8 a.m.	41°	2:07.7 a.m.	307°
2	5.3	63 Geminorum	8:36.4 p.m.	75°	9:30.1 p.m.	277°
4	6.5	102 B Cancri	6:15.3 a.m.	79°	7:26.2 a.m.	318°
4	6.3	Epsilon Cancri	6:19.7 a.m.	106°	7:38.8 a.m.	291°
27	3.9	Delta Tauri	3:50.9 a.m.	89°	4:49.5 a.m.	255°
27	4.8	64 Tauri	4:26.6 a.m.	122°	5:10.5 a.m.	222°
28	6.2	351 B Tauri	3:05.3 a.m.	102°	4:11.2 a.m.	250°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *December*, OLD-FASHIONED CHRISTMAS. (See page 12.)

In this production music and color, under the brilliant winter stars, revive memories of other Christmas seasons, and conjure up the joyful symbols which we associate with the spirit of an old-fashioned Christmas. Of all the things that stand for Christmas, more even than the yule log or mistletoe or holly, the star surmounting our Christmas tree takes us most significantly into the past. No one can be sure what that star might have been, but the magic of the planetarium projector transports us back to the Palestine of 2,000 years ago, where we view the possibilities astronomy suggests for the first of all Christmas stars.

★ **THE HAYDEN PLANETARIUM** presents in *December*, THE CHRISTMAS STAR. (See page 12.)

In *January*, UNDER THE WINTER SKY. For one month during each season of the year, the Hayden Planetarium gives a straight constellation-study demonstration, providing the observer with an opportunity to learn new and less well-known constellations and stars, and to become familiar with particularly interesting objects which he may have hitherto missed. Simple guide lines are shown, so the observer may find his way from one constellation to another. Starting with the Big Dipper, we travel by easy stepping stones to the far southern part of the sky. The winter sky contains star groups which are breath-taking in their brilliance.

★ SCHEDULE BUHL PLANETARIUM

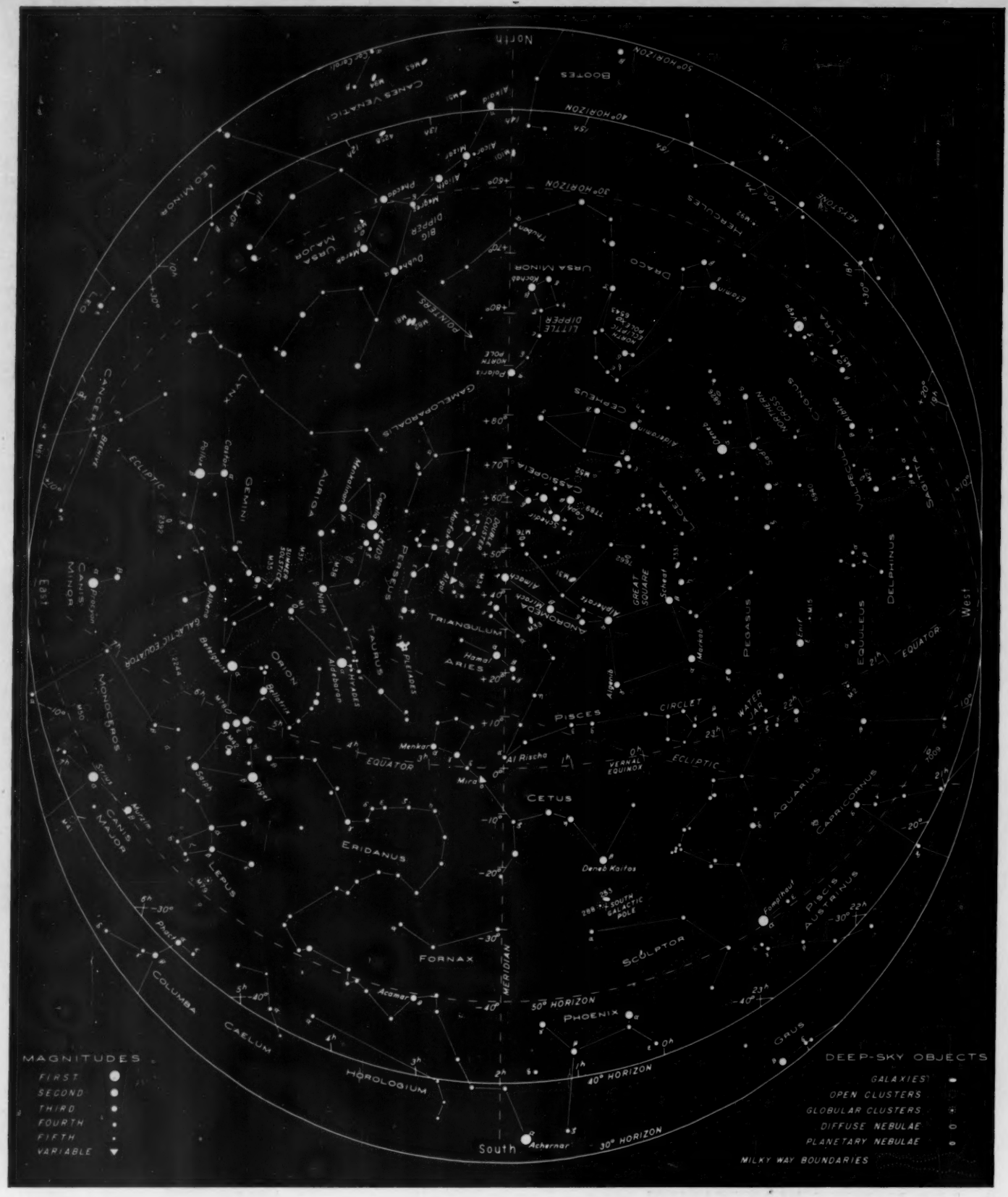
Mondays through Saturdays ..... 3 and 8:30 p.m.
Sundays and Holidays ..... 3, 4, and 8:30 p.m.

★ STAFF—*Director*, Arthur L. Draper; *Lecturer*, Nicholas E. Wagman; *Manager*, Frank S. McGary; *Public Relations*, John F. Landis; *Chief Instructor of Navigation*, Fitz-Hugh Marshall, Jr.; *Instructor, School of Navigation*, Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays ..... 2, 3:30, and 8:30 p.m.
Saturdays ..... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays ..... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Associate Curator*, Marian Lockwood; *Assistant Curator*, Robert R. Coles (on leave in Army Air Corps); *Scientific Assistant*, Fred Raiser; *Lecturers*, Charles O. Roth, Jr., Shirley I. Gale, John Saunders.



DEEP-SKY WONDERS

AMONG marvels for observation in the December skies are the objects listed here. The informal descriptions give appearance in common telescopes.

Auriga. M38, 5^h 22^m, $+35°$ 45′; a cluster of 100 stars. Nearby is M36, a group of 60 stars. M37, 5^h $45^m.8$, $+32°$ 31′, a delightful cluster of 150 stars.

Orion. M42, 5^h $31^m.3$, $-5°$ 26′; the Great Nebula, 900 light-years from earth. Note the trapezium of four stars, the black bay, and the waterspout (on the S.E.). Immediately north of M42 is M43, a mitten-shaped nebulosity. The top star of Orion's sword is one in a wide cluster above a fan of six stars in a nebular net. M78, 5^h $42^m.6$, $+0°$ 02′; two interpenetrating lobes of nebulosity, with a star in one and a wide double in the other. L. S. COPELAND

Chart correction: Cor Caroli, in Canes Venatici, should be 3rd magnitude.

STARS FOR DECEMBER

from latitudes 30° to 50° north, at 10 p.m. and 9 p.m., war time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.



EVENING STARS FOR SOUTHERN OBSERVERS

THIS is the third map in the series of star charts for use by observers in the Southern Hemisphere, and matching the northern maps. It is prepared for a basic latitude of 30° south, but may be used conveniently 20 degrees on either side of that parallel. These southern charts appear in alternate months, but always two or three months in advance, to allow time for transmission to observers in any part of the world. When 12 charts have been produced, and if interest warrants, a special edition of **Sky and Telescope** may be published each month carrying observing material for Southern Hemisphere observers. This chart is for use in latitudes 20° to 40° south on February 7th at 11 p.m., February 23rd at 10 p.m., March 7th and 23rd at 9 p.m. and 8 p.m., respectively. Times for other days vary similarly: four minutes earlier per day. These are local mean times which must be corrected for standard time and war time differences. The 30° horizon is a solid circle; the other horizons are circles, too, those for 20° and 40° south being dashed in part. When facing south, hold "South" at the bottom, and similarly for other directions. Observers in the tropics may find north circumpolar stars on any of our northern star charts.

STARS OR PLANETS?

(Continued from page 7)

known for some time. Now we note in our neighborhood the blossoming out of double into triple systems, and prolific increase of close unseen companions for single stars. For example, the nearest five stellar objects (Alpha Centauri, Barnard's star, Lalande 21185, Wolf 359, Sirius) are now known to contain two component *stars* on the average, and we wonder how exceptional single stars may prove to be. Nearly four decades ago, we find the same thought expressed by the spectroscopic observers, Campbell and Curtis (*op. cit.*):

"In fact, the star which seems not to be attended by dark companions may be the rare exception. There is the further possibility that the stars attended by massive companions, rather than by small planets, are in the decided majority; suggesting, at least, that our solar system may prove to be an extreme type of system, rather than a common or average type."

There are several aspects of stars and planets beyond the scope of the present article, as, for example, the problems of their origin, structure, and evolution. We conclude with drawing attention to the fact that our sun, though generously endowed with planets, is the only star that we surely know to have no close companion star.

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Amateur Astronomers

THIS MONTH'S LECTURES

Cleveland: On December 1st, Dr. Edwin Ebbighausen, of Allegheny Observatory, will address the Cleveland Astronomical Society on "When the Stars Come Out." The meeting is at 8:00 p.m. at the Warner and Swasey Observatory.

Detroit: "The Advent Star" will be the subject of the talk by Dr. Karel Hujer, Michigan State College, to the Detroit Astronomical Society, December 10th at Wayne University, 3:00 p.m.

Madison: "Other Sciences in Astronomy" will be the subject of this month's lecture by Lawrence Demmer, to the Madison Astronomical Society on December 13th. The group meets at Washburn Observatory at 8 o'clock.

New York: The president of the American Rocket Society, Dr. James H. Wyld, will speak to the Amateur Astronomers Association on "Rocketry and Jet Propulsion" on December 6th. The meeting is at 8:00 p.m. in the Roosevelt Memorial building of the American Museum of Natural History.

Worcester: "Sundials" will be discussed by R. Newton Mayall at the Aldrich Astronomy Club, 7:30 p.m., Tuesday, December 12th, at the Museum of Natural History.

DECEMBER ACTIVITIES

The Cincinnati Astronomical Association will have its annual dinner meeting on December 7th.

The New Haven Amateur Astronomical Association will hold a Christmas social at Yale Observatory on December 30th.

MAKING YOUR OWN TELESCOPE

(Continued from page 17)

ones usually at the center. As the abrasive is broken down, the surfaces approach each other more closely and the bubbles become smaller. If the central bubbles remain large, they indicate a gap at the center, as in Fig. 10. Carbo will be found to accumulate there. Lift off the mirror, and spread the Carbo evenly with the fingers, on both mirror and tool. Add water and grind this down. Repeat this process until the abrasive has been broken down quite fine. At this stage the mirror will be found to grab at the edges as the grinding strokes bring the centers coincident. This is caused by the suction of the central gap. Renew the charge of Carbo, and grind it down thoroughly, frequently re-distributing it with the finger.

These operations must be persisted in until the symptoms disappear, after which we try for a more exact determination of the radius. Flush off the disks in the pail of water, and wash the hands as well. Deposit about ⅛ teaspoon of #400 Carbo on the center of the tool, add a few drops of water, puddle it and spread it around with the finger. Grind this down for about five minutes, stopping in between to re-spread it. Then flush the mirror thoroughly, and stand it, wet, on the testing rack. Using the window of the Foucault lamp, or a flashlight, held alongside the eye, locate its reflection on the wet surface of the mirror. Move the light from side to side. If the reflection moves in the same direction, we are inside the center of curvature of the mirror. If it moves in an opposite direction, we are beyond center of curvature. When we are at a position where the reflection just seems to come and go, from no definite direction, as the light is moved from side to side, we are at the center of curvature, and this distance is to be measured exactly. One half of it is the focal length, and we should determine it within an inch at this stage.

By using the charge of #400, the surface is enabled to hold the water for a longer period. Even then we may have to interrupt the test to splash more water on the mirror. If the focal length is about 49", we are ready for #120. If it is too long, we must continue the one-third stroke with #80 until we bring it right. If it is less than 49", we have ground too deeply, and we should invert the positions of the disks, and grind with the tool on top. This will flatten the curve. Use the one-third stroke. Use of a longer stroke might seriously flatten the edge, so that it would not polish. The one-third stroke will lengthen the radius gradually without deforming the figure. When the proper focal length is arrived at, we again place the mirror on top, and continue with the one-third stroke to restore contact.

While the difference of a few inches in focal length either way will be of no material consequence, we have decided on a length of 48", and we may as well begin now to develop our skill for the tasks that lie ahead, and endeavor to arrive precisely at that figure.

Before going to the fine grinding, we clean up thoroughly, so there will be no possibility of any #80 ever getting near the mirror again. Clean up the water bottle, spoon, flashlight, water pail, Carbo stone, anything that we might have touched with #80. If, through prolonged grinding, the edge of the mirror has become sharp, bevel it carefully, and also bevel the tool.

(To be continued. Next month fine grinding and making the pitch lap will be described.)



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